

THE PRESENT POSITION OF RADIO-ACTIVITY.¹

THERE are three fundamental conceptions, the atom, the electron, and the ether. The seventy odd different kinds of atoms known, although fundamentally distinct, form a class to themselves in the complexity of matter, so that any discovery fundamentally affecting one must embrace all. The electron expresses for electricity the same idea as the atom does for any one kind of elementary matter, and may be termed the atom of negative electricity. Only one kind of electricity, and only one kind of electron, is known, and this possesses the same essential properties in all its various manifestations. The ether renders possible "action at a distance," and all actions transmitted through the ether are of essentially the same character and travel at one speed, namely, the speed of light.

The electron, although by origin an electrical conception, is in reality a material conception no less than the atom. At rest an electron is a simple charge—an electrostatic phenomenon. In motion it constitutes a current of electricity—an electromagnetic phenomenon. When an electron moves from rest to speed and back to rest again, the ether through which it moves at first has no magnetic qualities; then it acquires an amount of magnetic energy proportional to the speed of the electron, and then it again loses the same amount. Thus the electron cannot move without the expenditure of energy, and cannot be stopped until it has again given up the same amount. According to Newton's laws of motion, therefore, the electron is essentially a material particle. It possesses inertia, or "apparent mass," but it is not yet known whether it obeys the law of gravity, and possesses gravitational mass.

Since action at a distance travels through the ether at the speed of light, the magnetic field at a point some distance away from the line of motion of an electron cannot instantaneously accommodate itself to a change of motion of the electron, but the disturbance of the magnetic field travels outward from the electron with the speed of light. If the change of motion of the electron is periodic, as in the case of an electron revolving in an orbit within an atom, the disturbance constitutes ordinary light. In the Crookes's tube there is an irregular shower of free-flying independent electrons (kathode rays) upon the anti-kathode. The sudden irregular disturbances in the magnetic field travelling outward from the anti-kathode at the speed of light constitute the X-rays. The Hertz waves, on the other hand, result when electrons are caused to oscillate along paths of metrical rather than molecular dimensions, and their wave-length is measured in metres rather than in molecular diameters.

The apparatus employed largely to generate what are known to medical men as "high-frequency currents" admirably illustrate the inertia of electrons. Such a current will jump an air gap rather than traverse a spiral rod of copper, and will light a high-resistance incandescent lamp "short-circuited" by loop of bar copper. Lightning possesses the same characteristics, as Sir Oliver Lodge was the first to demonstrate.

The question arises whether there are two kinds of inertia, essentially similar, the one "material" and the other electromagnetic. If a sufficient number of electrons could be concentrated within a space of atomic dimensions, the total inertia of the aggregate could be made equal to that of an atom. Unfortunately, we know of no means whereby the mutual repulsions of the electrons could be overcome without introducing the hypothetical positive electron or its equivalent.

The present year is the decennary of M. Henri Becquerel's discovery of the natural radio-activity of matter. Radio-activity has been interpreted as the effect of a process of spontaneous disintegration occurring within the atoms of the radio-element, and already atomic disintegration is recognised as the probable cause of innumerable hitherto isolated phenomena in every branch of knowledge. It is the most fundamental and potent factor of evolution known. The ultimate cause of atomic disintegration, like that of most other common properties of matter, even gravitation, remains quite unknown. The view that radio-

activity is the outward and visible sign of deep-seated material change followed from the elucidation of the nature of the emanations, and of the phenomenon of excited or induced activity. It was shown that the emanations and the allied bodies were new forms of matter continuously being produced from the radio-elements, and that they were the products of the changing atoms. Rutherford's discovery that the α radiation consisted of radiant particles, and the gradual accumulation of evidence, amounting to-day to practical proof, that the α particles are radiant atoms of the element helium, enabled the whole process to be simply elucidated. A single radiant atom is within the means of detection, for example, by the spinthariscopes, whereas a million million atoms is not sufficient to be detected by the most delicate and refined spectroscopic test. The radio-atom suffers successive disintegration, and at each disintegration a single radiant particle is in general expelled. The radium atom successively expels five α particles, so that a residue of atomic weight about 205 should be left if these particles are helium atoms. There is strong indirect evidence for believing that the residue atom is that of lead. In the natural minerals, where the radio-elements occur, are to be found the ultimate products of ages of past accumulation. In the uranium minerals, helium, radium, polonium, and lead have been recognised as the constant companions of the uranium. Direct experiments have established in each case, except lead, the production of these elements during the disintegration. Polonium is the last changing member of the disintegration series, is a higher homologue of tellurium (Marckwald), and is identified with the radium F of Rutherford. The production of lead from polonium has not yet been directly observed, but Boltwood has shown it to be a constant constituent of the uranium minerals.

There is a comprehensiveness and subtlety in the operations of the laws of nature which the most vivid imagination cannot anticipate. The fact that the proportion of radium in any uranium mineral must be constant, being the ratio between the rate of disintegration of radium and that of uranium (or one to a million), cannot fail to have most important bearings. If to-morrow radium could be imported in quantity from outer space, after a few thousand years the quantity in the earth would be no more and no less than at present. By that time the quantity exhibited to-night will have had its day and ceased to be, but if the rest of the mineral from which it was extracted could again be examined a new amount no less than that originally present would be found to have grown in the interval.

How far are we justified in extending these ideas to explain analogous phenomena in the case of the inactive elements? We know that radio-activity is a mere accompaniment by no means essential to the process of atomic disintegration. The evidence available shows clearly that atomic disintegration might be universal and yet beyond the power of direct detection. A discovery fundamentally affecting any one element must embrace the whole class. The internal energy of the atom is merely revealed in radio-activity, in the same way as the internal energy of gun-cotton is revealed only when it explodes. The energy of the disintegration of an element is roughly a million times greater than that of any other change we are acquainted with. The attempt of the alchemist to build up a heavy element like gold from silver was futile, because, even if it could be done, it could not pay. The energy of some hundreds of tons of coal would have to be put into an ounce of silver to convert it into gold; but if gold could be formed from the degradation of a heavier element like lead, the gold would be a mere by-product, and the store of energy liberated simultaneously, however reckoned, would be of far greater value than the gold produced. At present we are totally ignorant of any means of altering or affecting in any way the rate of atomic disintegration proceeding spontaneously, or, in other words, we cannot effect artificial transmutation.

The experimental sciences do not hold out much hope of giving an immediate answer to the question whether atomic disintegration is general, and whether the scarcity or abundance of an element in the earth is a measure of its stability. We are forced back on such indirect evidence as lies ready to our hand. It is possible to obtain such evidence in the field of economics for the element gold,

¹ Abridged from the presidential address delivered to the Röntgen Society on January 4 by Mr. Frederick Soddy.

because gold has been established by long experience to be an excellent if not ideal metal for coinage. Analysing what this means, we find that an extremely complex condition must be satisfied. We are not a stereotyped or stagnant civilisation, and the demand for coinage metal experiences great fluctuations. With the scientific awakening of last century, an enormously increased demand arose in consequence of the rapid extension of commerce. In spite of this it is of the utmost importance that the value of other commodities expressed in terms of that of the coinage-metal must remain fairly constant from year to year, otherwise debtors and creditors might awake to find themselves ruined by some great variation in the value-ratio. Experience shows that this complex condition is, as a matter of fact, nearly fulfilled for the element gold. The first requirement that gold possesses enabling it to fulfil the condition is that it is a technically worthless metal. It possesses usefulness only on account of its value. Platinum, on the other hand, is unsuited for coinage because it possesses value on account of its usefulness. In the latter case the demand increases with fall of price, while in the former it decreases.

The second requirement that has to be satisfied if the value-ratio is to remain constant is that the output of gold should, on the average, bear some fixed ratio to the amount of human endeavour expended in the search. The scarcity must be relative, and some definite number of tons of the auriferous material must on the average be extracted to produce an ounce of the metal. That is to say, the scarcity must be mainly of concentration, as in the case of radium in the uranium minerals. If a technically worthless metal is a member of a disintegration series, so that its concentration in its ores is on the average fixed, it would obey the complex condition required for a coinage metal. So that the argument may be inverted, and indirect evidence obtained that gold is, like radium, a member of a disintegration series. The gold currency cost the world seventy million pounds worth of unproductive labour last year. A sum, which expressed in pounds runs into ten figures, representing the world's accumulated stock of bullion, has been *spent* in the past. To-day it exchanges at its face-value; to-morrow, with the introduction of a less expensive and more scientific system of book-keeping, it will become a mass of technically worthless metal.

This extension of the idea of atomic disintegration shows how powerfully the recent theories are bound in time to affect the life and thought of the community. Those who have grasped their significance know well that nothing appears the same or can again appear quite the same as before. It is not necessary that we should ever approach nearer than at present to the control and application of the new processes and reservoirs of energy. The mere possibility of being able to do so in the future cannot fail to leave its mark. By these discoveries the relation of mankind to nature has undergone a certain change, and man has caught a glimpse of some latent possibilities within his legitimate destiny which cannot be effaced. Energy is the life of the physical universe. You cannot multiply the existing store by a million and leave things as they were. Man, "nature's rebel," as Prof. Ray Lankester has depicted him, left isolated among the forces of nature to work out his own salvation, has had placed before his eyes a new material destiny. So far as physical possibility is concerned, he may one day attain to the power as well as the wish expressed in the quatrain of Omar:—

"O love! could you and I with fate conspire
To grasp this sorry scheme of things entire,
Would not we shatter it to bits—and then
Re-mould it nearer to the heart's desire!"

MEDICAL INSPECTION AND FEEDING OF CHILDREN IN SCHOOLS.¹

WE welcome this extension of the inquiry begun in the physical deterioration report, however limited be the terms of reference, viz. (1) to report on what is being done, and with what result, in respect to medical inspection; (2) to inquire into the methods employed, the sums

¹ Report of Interdepartmental Committee on Medical Inspection and Feeding of Children attending Public Elementary Schools. (Cd. 2779.) Price 1s. 3d.

expended, and the relief given by various voluntary agencies for the provision of meals, and to report whether relief of this kind could be better organised without any charge upon the public funds.

(1) Upon the first subject, the results are shown to be most beneficial, the percentage of sufferers being by no means small; thus in defects of vision found in 7 per cent. to 20 per cent. of children examined, headache and apparent dullness often disappear. Twenty per cent. seems a common experience of the incidence of vermin, uncleanness, and ringworm; here beneficial results have been generally of a marked character, cases being diminished by one-half in nine months in Gloucestershire.

The medical officer of health at Salford demonstrates to the teachers the symptoms to expect in infectious diseases, and the teachers are becoming so skilful in detecting symptoms, and at once excluding all suspected cases, that outbreaks of infectious disease demanding medical inspection are much less frequent. So will necessity for closing the schools diminish.

Diphtheria, it is stated, is now in several areas under such complete control that it can be stopped in a few days. We read in this and similar evidence an urgent call for the extension of medical inspection, and regret that the committee should water their conclusions with a comment that the "results" are to be given as statements of opinion rather than as ascertained facts. The contrary is the case, the facts are ascertained, and if the dozen witnesses coincide, surely we have progressed beyond opinion.

(2) In the second inquiry, in which the committee is to report whether relief can be better organised without any charge upon the public funds, much valuable sociological information has been collected. In many schools 2 per cent. to 5 per cent. of children require this aid, and a meal may cost from a penny to twopence. Seventeen recommendations outline business-like cooperation for charitable relief.

The committee has stated that in the ordinary run of cases which will come up to be dealt with, a woman's opinion upon the need of a household will be more valuable than a man's, and the opinion of two lady witnesses is given that the existing attendance officer is not sufficiently trained, and therefore of no use for the purpose. One would imagine a recommendation would follow that a lady official should be secured for this primary duty of selection of recipients. This omission does not seem explicable on financial grounds, for it might as readily be a charge upon voluntary subscription as upon the public funds. One feels that without such aid the frequent abuse of free meals, as reported in the evidence, is likely to recur.

In this inquiry, all who seek to avoid pauperising parents on the one hand, or the underfeeding of school children on the other, will find much useful information.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—By the will of the late Sir J. S. Burdon-Sanderson, the laboratory of the pathological department of the University is bequeathed the sum of 2000l., payable within six months of his death, as an endowment to provide for pathological research there, the fund to be vested in the professors for the time being of human anatomy, physiology, and pathology, who are to have absolute discretion as to the application of the fund.

CAMBRIDGE.—Last Sunday completed the fiftieth year during which Dr. Atkinson has presided as Master over the fortunes of Clare College, and the University will on February 1 present him with an address of congratulation similar to that presented to the late Lord Braybrooke two years ago.

Mr. H. O. Jones, of Clare College, has been approved as deputy for the Jacksonian professor of experimental philosophy during the current Lent term.

The following awards to scholarships in mathematics have been made at Queens' College:—N. R. Krishnamma, Merchant Taylors', 45l.; C. F. Waterfall, Manchester Grammar School, 45l.; A. H. Pinder, Malvern College,